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WATER SUPPLY AND WATER QUALITY CONTROL STUDY TAR RIVER BASIN NORTH CAROLINA

Federal Water Pollution Control Administration
Charlottesville, Virginia

December 1967

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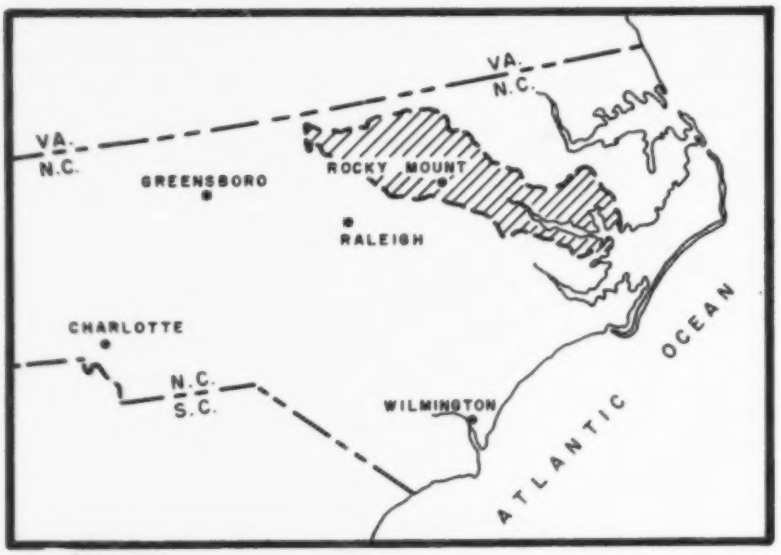
WATER SUPPLY AND WATER QUALITY CONTROL STUDY TAR RIVER BASIN NORTH CAROLINA

STUDY OF NEEDS AND VALUE OF STORAGE FOR WATER SUPPLY AND WATER QUALITY CONTROL



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U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION
CHARLOTTESVILLE, VIRGINIA
DECEMBER 1967

WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
TAR RIVER BASIN
NORTH CAROLINA

ABSTRACT

A study of the need for and value of streamflow regulation for water quality control and municipal and industrial water supply has been made for the Tar River Basin, North Carolina. The future water needs were based on the results of economic and demographic studies of the area. It was concluded that water quality control measures beyond secondary waste treatment were necessary to protect the beneficial water uses in the basin.

PREPARED AT THE REQUEST OF THE

U. S. ARMY ENGINEER DISTRICT

WILMINGTON, NORTH CAROLINA

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U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Middle Atlantic Region
Charlottesville, Virginia

December 1967

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I. INTRODUCTION

REQUEST AND AUTHORITY

The District Engineer, U. S. Army Engineer District, Wilmington, North Carolina, requested by letter dated July 21, 1965, that the Public Health Service 1/ study the water resources of the Tar River and evaluate the need for and value of storage for water supply and water quality control.

The study was made in accordance with the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq).

PURPOSE AND SCOPE

The objectives of the study were to determine the economic growth and to evaluate the need for and value of storage for water supply and quality control for the Tar River Basin. The study area consists of the entire Tar drainage basin, which includes all or parts of eleven counties.

The period of study covers the present and the 50-year period commending in 1975, and extending to 2025. The needs for water supply and quality control storage were determined for the years of 1980, 2000, and 2025.

1/ Pursuant to the Reorganization Plan No. 2 of 1966, Water Pollution Control functions were transferred from the Department of Health, Education and Welfare to the Department of the Interior, May 10, 1966

ACKNOWLEDGMENT

U. S. Army Engineer District, Wilmington, North Carolina

U. S. Geological Survey, Raleigh, North Carolina

U. S. Bureau of Sport Fisheries and Wildlife, Atlanta, Georgia

North Carolina Board of Water and Air Resources, Raleigh, North Carolina 1/

North Carolina State Board of Health, Raleigh, North Carolina

North Carolina Fish and Wildlife Service, Raleigh, North Carolina

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1/ Formerly two organizations consisting of North Carolina State Stream Sanitation Committee and Board of Water Resources

II. SUMMARY OF FINDINGS AND CONCLUSIONS

FINDINGS

1. The study area encompasses the Tar River Basin and includes all or parts of eleven counties. The drainage area of the basin is approximately 3,080 square miles.

2. The population of the study area was approximately 399,400 in 1960. The study area is primarily rural and in 1960 the urban population accounted for 30.6 percent of the total population compared to 39.5 percent for North Carolina, and 70 percent in the Nation.

3. The economy has been dominated by the agricultural sector in which tobacco production has played an important role. Manufacturing has been of secondary importance and concentrated in furniture, lumber, textiles, food processing, and apparel industries.

4. There are presently 27 significant sources of waste in the basin, of which 19 provide secondary treatment, 6 primary treatment, and 2 provide treatment for inorganic wastes. The total waste load generated in the basin is approximately 15 million gallons per day (mgd) with a population equivalent (P.E.) of 153,000. The mean efficiency for all treatment plans is about 80 percent in terms of Biochemical Oxygen Demand (BOD) removal and represents a discharge of 31,000 P.E. to the receiving stream.

5. There are six major municipalities in the basin, all of which use surface water for water supply. The present municipal water use is approximately 17 mgd. All the major industries in the basin obtain their water from municipal systems with the exception of Rocky Mount and Greenville steam power plants. The two plants use approximately 38 mgd of water from the Tar River for cooling purposes.

6. The quality of surface water in the basin, in general, meets the requirements for present water usage with the exception of low dissolved oxygen levels in some of the minor tributaries near primary treatment plant waste outfall. Groundwater quality is satisfactory throughout the basin.

CONCLUSIONS

1. Population of the study area is expected to increase to 480,000 by the year 2025. The urban population is expected to reach 55 percent of the total population (264,000) in 2025.

2. The municipalities of Oxford, Rocky Mount and Henderson are in need of additional water supply. The City of Rocky Mount is nearing the construction stage for expansion of existing facilities and Oxford and Henderson are in the preliminary planning phase. A 10 mgd impoundment on the Tar River would meet all the future water needs for Oxford. The City of Henderson is planning to take water from the John H. Kerr Reservoir, which will meet all future needs.

3. Based on economic projection and estimated waste loadings, water quality control measures in addition to secondary treatment facilities will be necessary by 1980 to protect beneficial stream uses.

4. Flow regulation and advanced waste treatment was studied and it was determined that the most economical water quality control plan for the basin would be to construct a single purpose reservoir with a storage capacity of 11,000 acre-feet at the proposed Spring Hope site. The average annual cost for flow regulation was estimated to be $74,700 as compared to $173,100 for advanced waste treatment.

5. A multi-level outlet structure would be required for the reservoir to provide for the release of high quality water and improve tail water fishing. Stream monitoring equipment should be installed downstream to provide information to be used for determining reservoir releases and developing a water quality management program for the basin.

6. Flow regulation would protect approximately 90 miles of stream for fish and wildlife, recreation, other than water contact sports, and aesthetics. Secondary treatment providing a minimum of 85 percent removal as measured by BOD and disinfection of effluents would provide protection for water supply uses.

7. The values of water quality control benefits for municipal and industrial water supply were determined and found to be negligible; however, intangible benefits would be realized. The tangible value of fish and wildlife benefits was evaluated by the U. S. Bureau of Sport Fisheries and Wildlife and estimated to be $5,100 annually. The annual value of the fishery which is being protected is estimated to be $64,800.

8. The intangible benefits associated with recreation, aesthetics, and fishing which result from adequate water quality control measures were considered; however, a suitable rational for expressing these benefits in monetary terms is not presently available. Even though a value cannot be determined the beneficial water uses will be protected through the established Water Quality Standards, and implementation of water quality control measures.

9. The water supply benefits for the City of Oxford would be equal to the cost of a single purpose reservoir located on the Tar River with a storage capacity of 5,900 acre-feet. The average annual benefits are estimated to be $16,700.

III. DESCRIPTION OF PROJECT

The Wilmington District, Corps of Engineers, in accordance with the resolution adopted June 28, 1962, by the Committee on Public Works of the United State Senate, initiated a study of the Tar River Basin to determine the needs for flood protection, water supply, recreation and water quality control. Four reservoir sites have been tentatively selected for multi-purpose development. The proposed Grey Rock and Spring Hope sites are located on the main stem of the Tar River. The Red Oak site is on Stony Creek and White Oak on Fishing Creek. (See Figure 1).

Preliminary estimates indicate the conservation pool capacities to range from 35,000 to 53,000 acre-feet. Final reservoir sizing and storage allocations are currently being evaluated.

IV. DESCRIPTION OF STUDY AREA

LOCATIONS AND BOUNDARIES

The study area for the Tar River Basin includes approximately 3080 square miles and is entirely within the State of North Carolina. The basin lies between the Roanoke and Pasquotank River Basins on the north, and the Neuse River Basin and the Pamlico River on the south.

The Tar River rises in the Piedmont Plateau of North Carolina, near the village of Mill Creek in Person County, and flows in a southeasterly direction through the Piedmont Region, and the Coastal Plain, emptying into the Pamlico River at Washington. The Pamlico River continues in a southeasterly direction for a distance of approximately 40 miles to Pamlico Sound. The principal tributaries of the Tar River are Swift Creek and Fishing Creek. (See Figure 1).

GEOGRAPHY AND TOPOGRAPHY

The upper one-fourth of the Tar River Basin lies in the Piedmont Plateau, characterized by low, rounded hills and wide stream valleys. Elevations in the area range up to 600 feet above sea level. The remaining area lies in the Sandhills and Coastal Plain region, with elevations ranging from 200 feet near the eastern edge of the Piedmont Plateau of sea level to sea level on the coast. The Tar River has a total fall of 550 feet from its source to the Pamlico River.

CLIMATE

Temperatures of the basin may be described as moderate due to the location of the area in the warm temperate zone and the relatively small variation in elevation. Mean annual temperatures range from 62.5° F on the coast to 58.5° F in the extreme upper part of the basin. Temperatures of over 100° F are occasionally recorded in the summer and freezing weather occurs with moderate frequency during the winter.

Average rainfall for the basin is approximately 46.5 inches and ranges from 45 inches at Oxford to 48.5 inches at Washington. Monthly precipitation is quite evenly distributed with the maximum usually occurring in July or February, and the minimum in November. Droughts have occurred frequently over the basin with the most severe in 1921.

PRINCIPAL COMMUNITIES AND INDUSTRIES

Principal communities in the basin with populations greater than 5,000 are Oxford, Henderson, Rocky Mount, Tarboro, Greenville, and Washington. The municipalities of Rocky Mount, Tarboro, and Greenville are located on the Tar River, and Washington is located at the confluence of the Tar and Pamlico Rivers.

Major industries are closely allied with agricultural operations and products. Furniture, lumber, textile, and apparel industries are scattered throughout the basin. Several industries engaged in tobacco and textiles are located at Rocky Mount and Greenville.

V. WATER RESOURCES OF THE STUDY AREA

SURFACE WATER

1. Quantity

Water resources of the Tar River Basin are undeveloped and streamflows are primarily uncontrolled with the exception of daily fluctuations caused by small mills and a run of the river hydroelectric impoundment at Rocky Mount. Streamflows are influenced by small water supply reservoirs, farm ponds, and inter-basin transfer of water; however, the magnitude of withdrawals and transfer is small compared to the total water resources of the basin.

There are three U. S. Geological Survey streamflow gages located on the Tar River at river miles 93, 143, and 203, and these gages have continuous records for 39, 38, and 27, years respectively. Historical data were used to determine the streamflows at the major use points in the basin which are the proposed water supply reservoir sites for Rocky Mount, river mile 159, and the water supply intake at Greenville, river mile 66. Flows were adjusted on a drainage area basis from the nearest streamflow gage and a summary of the annual mean historical flows for the locations are shown in Table V-1.

Table V-1

Location (River Mile)	Years of record at nearest gage	Drainage area (Sq. miles)	Mean Flow (cfs)	Standard Deviation(cfs)
159	38	660	708	568
66	39	2,620	2,765	2,367

A mathematical model that utilizes statistical analysis of historical streamflow data and a stochastic hydrology method were used to synthesize long traces of hydrometerological data on a seasonal or monthly basis. Monthly mean flows and standard deviations for the generated traces at river miles 159 and 66 are presented in Table V-2.

Table V-2

Month	River Mile 159 Mean Flow (cfs)	River Mile 159 Standard Deviation (cfs)	River Mile 66 Mean Flow (cfs)	River Mile 66 Standard Deviation (cfs)
October	422	489	1,360	2,120
November	550	490	1,650	2,130
December	762	585	2,710	3,060
January	1,070	852	4,260	4,370
February	1,280	838	5,310	4,060
March	1,130	503	4,750	2,110
April	1,060	546	4,150	2,470
May	595	315	2,160	1,400
June	420	258	1,450	1,030
July	481	365	1,970	1,820
August	550	654	2,420	3,800
September	494	828	2,610	5,980

Statistical analysis of the historical flows indicates large standard deviations for the months of October, November, August and September. Extremely high and/or low flows can occur during these months indicating a very "flashy" stream.

The greatest deficiencies in streamflow can be expected to occur during the months of August, September and October, under natural uncontrolled conditions.

2. Quality

The quality of surface water in the Tar River Basin, in general, meets the requirements for current water usage with the exception of high coliform concentrations in the Tar River above Washington and low dissolved oxygen levels in some of the minor tributaries. Below the waste treatment plant outfalls for the communities of Oxford, Franklinton, Spring Hope, Littleton, Enfield, Whitaker, Elm City, Pinetops and Robersonville, the dissolved oxygen concentrations drop below 4.0 milligrams per liter (mg/l). These communities are located on minor tributaries and before reaching the Tar River the dissolved oxygen levels exceed 4.0 mg/l.

During the summer of 1958, the North Carolina Department of Water and Air Resources conducted a stream sampling study of the basin and the results indicated that dissolved oxygen levels ranged from 5.7 to 8.3 mg/l, in the Tar River, Swift Creek and Fishing Creek. Coliform levels were greater than 5000 per 100 milliliter in the Tar River from the community of Washington to a point near Oxford. A summary of the results of the sampling program are shown in Table A of the Appendix.

It should be noted that the above discussion on water quality was based on information obtained during the 1958 study. Subsequent to that time waste treatment facilities have been constructed or expanded and water quality within the basin has been improved.

Chemical analysis of surface raw water supplies for various communities in the basin are shown in Table B of the Appendix. Iron is the only constituent which exceeds the recommended finished water quality objectives of 0.3 mg/l and has a range of 0.06 to 0.57 mg/l. The higher concentrations, however, can be easily reduced with conventional water treatment facilities.

Mean water temperatures for various stations on the Tar River range from a low of 38° F in the winter to 82° F in the summer. Currently the stream temperatures are within the range suitable for the propagation of a warm water fishery.

GROUNDWATER

1. Quantity

Groundwater occurrence in the Tar River Basin is divided into two major classes, the igneous and metamorphic rock of the Piedmont area, and the sedimentary deposits of the Coastal Plain. In the Piedmont the groundwater moves through joints and fractures in the consolidated rock and in the coastal plain through the pore space in the unconsolidated sand, clay and lime.

The larger supplies of groundwater in the Piedmont area are from wells that penetrate fractured rock. The water derived from granite, mica, gneiss and schist is usually soft and low in mineral content. Well yields in this area vary from 55 to 300 gallons per minute (gpm).

In the Coastal Plain large groundwater supplies are available in the southeast where the unconsolidated sediments are the thickest. The well yields in this area vary from 25 to 1000 gpm.

The quantity of water withdrawn from the Coastal Plain is small compared to the amount available; therefore little attention has been given to the total perennial yield. It has been estimated that recharge in this area could reach approximately 1,000,000 gallons per day per square mile; however, because of losses through transpiration, evaporation, and streams only part of this is recoverable. In general, it has been assumed that the aquifers in the Coastal Plain could safely produce 500,000 gallons per day per square mile.

2. Quality

The quality of groundwater in the Tar River Basin varies according to location and geological information. In general, the quality is satisfactory throughout the basin. Table C in the Appendix shows the chemical concentrations for groundwater supplies in the basin.

VI. THE ECONOMY

INTRODUCTION

As approximated by county boundaries in this Economic Study Area, the Tar River Basin includes all or parts of the North Carolina counties of Beaufort, Edgecombe, Franklin, Granville, Halifax, Hyde, Nash, Pitt, Vance, and Warren.

The Study Area had a 1960 population of 399,400 and covers 5,634 square miles representing 8.8 percent of North Carolina's population, but 11.5 percent of its area. Educational attainment and per capita income are below average.

The Study Area's rural aspect is indicated by its municipal population. In 1960, urban population accounted for 30.6 percent of total population compared to 39.5 percent in North Carolina and 70.0 percent in the Nation. The six largest municipalities with their 1960 populations are presented below.

Greenville	22,900
Henderson	12,700
Oxford	7,000
Rocky Mount	32,100
Tarboro	8,400
Washington	9,900

The economy has been dominated by the agricultural sector in the past in which tobacco production has played an important role. Manufacturing has been of secondary importance, measured by employment, and has been concentrated in furniture and lumber, textiles, food processing, and apparel industries.

The general trend in manufacturing employment is for a greater concentration in the five counties of Edgecombe, Franklin, Granville, Nash, and Pitt relative to the total Area. Although the economic base is shifting from agriculture, the increase in manufacturing and services has not been rapid enough to prevent a large out-migration of excess labor released from an increasingly efficient agricultural sector.

Apparel and food processing is projected to realize the greatest gains in the future followed by machinery and electrical machinery. However, textile mill employment will still account for the largest portion of manufacturing employment. (See Table VI-1.) A fuller discussion of the above trends follows.

PRESENT ECONOMY

1. Agriculture

Agriculture as measured by employment is by far the most important industry in the Area although declining from 51 percent of total employment in 1950 to 42 percent in 1960. By way of comparison, agricultural employment in the State accounted for 30 percent of total employment in 1950 and only 21 percent in 1960. (See Table VI-1 for Basin employment figures.)

Tar River Basin Study Area
Agricultural Statistics

Study Area	1954	1964	Pct. of Total 1954	Pct. of Total 1964
No. of Farms	34,460	19,623	100	100
No. of Tenant Farms	21,814	9,488	64	56
No. of Farms Selling Under $2,500 Annual Products	11,178	1,886	32	10
Over $10,000 Annual Products	1,167	5,947	3	30
Land in Farms (thousands of acres)	2,340	2,143		
Average Size of Farms (acres)	68	109		

As the above table indicates, the number of farms are declining while the average size and average gross income are increasing. National trends manifest a similar character. These changes have been brought about by greater use of fertilizers, better seeds, more advanced farming methods, and by greater mechanization.

On a constant dollar basis (1914-19=100), the total value of farm products sold increased from $57 million in 1954 to $79 million in 1964. Crops still account for the major portion of the total value of farm products sold (94 percent in 1954 and 90 percent in 1964) but are dominated by the production of tobacco, corn, soybeans, and peanuts. Tobacco is the most important cash crop, and tobacco production figures reflect the increase in efficiency that has taken place. During the decade 1954-1964, tobacco production increased from 181 million pounds to 205 million pounds, whereas the total tobacco acreage decreased from 155,000 acres to 94,000 acres.

Livestock and livestock products, excluding dairy and poultry products, were second in importance accounting for 4.0 percent of total farm sales in 1954 and 5.0 percent in 1964. The most significant change in agricultural production was in poultry products, increasing from 1.0 percent of total farm sales in 1954 to 3.0 percent in 1964. On a constant dollar basis, the value of poultry sales increased from $789 thousand to $1.4 million. Dairy products increased from 1.4 percent of total farm sales in 1954 to 1.9 percent in 1964.

Agricultural efficiency in the Study Area shows a definite improvement. Indications are that the improvements have not taken place as rapidly as they have in North Carolina as a whole.

Irrigation in the Study Area is closely related to the production of tobacco. In the 1959 Census of Agriculture, 10,500 acres were irrigated. The 1964 Census of Agriculture gives the total land irrigated as 26,000 acres. This represents an increase of about 2.5 times the 1959 figure. The 1964 data shows that 82 percent of total acreage irrigated is for tobacco products. The average application of water per acre is about six inches during the growing season. This varies, of course, depending upon rainfall.

2. Forestry

Forestry lands are estimated to cover 60 percent of the total area. The general trend is for the proportion of the total forested area in softwoods, primarily pine, to decline and be replaced by lower-valued hardwoods. During the decade 1950-1960, the total area of softwoods declined by approximately nine percent while hardwood areas increased about ten percent. The net growth of pine, though, increased an average of one percent per annum while hardwood growth exceeded the annual cut by about nine percent.

The output of pulpwood has declined between 1954 and 1964 by approximately 1,000 cords. Production in 1964 was 31,461 cords. All of the pulpwood is shipped out of the Basin for processing as there are no pulpwood mills in the Basin.

3. Manufacturing

As Table VI-1 shows, manufacturing employment is the second most important category, accounting for 15.7 percent of total employment in 1960. By way of comparison, manufacturing employment accounted for 31.1 percent of total employment in the State and 27.1 percent in the Nation in 1960. Table VI-1 indicates that traditionally low-wage industries such as food processing, textile, apparel, and lumber industries were dominate in manufacturing employment in 1960.

The general trend over the decade 1950-1960 has been for manufacturing employment to concentrate in the five counties of Edgecombe, Franklin, Granville, Nash, and Pitt. County manufacturing employment as a percent of total Study Area manufacturing employment is presented below. All other counties in the Study Area manifest a decline.

Counties	Percent of Total Manufacturing Employment 1950	1960
Edgecombe	12.7	14.1
Franklin	7.5	8.3
Granville	5.2	6.1
Nash	11.8	16.6
Pitt	8.1	13.1
Total	45.3	58.3

There are three centers of manufacturing concentration within the Tar River Drainage Basin that deserve mention. They are the cities of Henderson in Vance County, Greenville in Pitt County, and Rocky Mount lying on the border of Edgecombe and Nash Counties. Henderson lies on the drainage border between the Tar and Roanoke Rivers, but discharges approximately 15 percent of its treated effluent in the Tar River Basin. Although comparable figures between these municipalities and the Study Area are not available, an approximate check can be arrived at by using the 1964 North Carolina Directory of Manufacturing Firms. This publication gives the total number of manufacturing establishments located at Henderson as 36, at Greenville as 41, and at Rocky Mount as 73. The three cities combined represent approximately 30 percent of the total number of establishments.

4. Population

The Study Area has experienced a small increase in population during the decade 1950-1960, averaging 0.1 percent per annum. (See Table VI-1 for population figures.) By way of comparison, North Carolina's population increased at an annual rate of 1.2 percent. The major reason for the difference in growth rates is the occurrence of out-migration from the Study Area. Between 1950 and 1960, a net out-migration of 76,275 persons took place,1/ representing 19 percent of the total 1950 population. This exodus has been brought about by better communications and greater mobility together with a lesser

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1/ Net Migration of the Population, 1950-60, by Age, Sex, and Color. Vol. I, Part 3. Economic Research Service, U.S. Department of Agriculture.

demand by manufacturing and the service sectors. Of the total net out-migration, 52 percent were in the 20-34 age group. The addition of the age group 35-49 (the two groups considered the most productive) would account for 64 percent of the total net out-migration. The above out-migration of younger persons helps to account for the increasing age of the population. In 1950, persons 50 years old or older accounted for 16 percent of total population while accounting for 19 percent in 1960.

Using income data prepared by the State, per capita income in 1960 was 36 percent greater than in 1949 while being 52 percent greater in the State.1/ Per capita income amounted to $878 in 1960 compared to $1,260 in the State and $1,853 in the Nation.

Urban population increased from 26 percent of total population in 1950 to 31 percent in 1960. During the same period, urban population in the State increased from 34 percent of total population to 40 percent.

FUTURE ECONOMY

1. Agriculture

Agriculture is expected to remain an important employment category although declining from 60,800 in 1960 to 36,500 in 1985. (See Table VI-1.) Greater diversification will take place with less dependence being placed on tobacco, corn, soybeans, and peanuts. Tobacco production is expected to remain a major cash crop but to account for a smaller proportion of total farm sales. Vegetable and poultry products are expected to increase their portion of total farm sales.

2. Forestry

The physical output of forestry products is expected to level off by 1975 except for pulpwood. National demands for pulp are projected to increase substantially, and these demands will cause an increase in pulpwood production in the Study Area. Better timber management can be expected by way of consolidation of timber lands and greater emphasis on softwoods.

1/ Personal Income Statistics for North Carolina Counties, 1949-1959. Summer 1963. Prepared by the Department of Conservation and Development and the Division of Community Planning, Raleigh, North Carolina.

3. Manufacturing

Manufacturing is the key to greater economic development in the Area. As indicated in the Present Economy section above, the Area is still basically a rural area. Favorable factors that could facilitate manufacturing are potential agricultural production, closeness to markets, adequate transportation facilities, and adequate water of good quality.

There are two major unfavorable factors that will tend to hold back the development of manufacturing. They are the lack of natural resources other than for agricultural potential and water, and a rather narrow manufacturing base upon which expansion can take place.

The manufacturing of agricultural products will depend upon the degree of shift from the present dependence on tobacco, corn, soybeans, and peanuts to products lending themselves to canning and preserving such as vegetables and meat products, particularly poultry. Manufacturing plants handling these type products must locate near their raw material source. Vegetables and poultry products have increased in total output in the past, poultry products at a faster rate than vegetables, and are expected to show a greater rate of increase in the future than total farm sales.

The Area appears to be adequately served by both railroads and highways. Raleigh lies some 65 miles west of Rocky Mount, the largest municipality actually in the Tar River Basin, and Durham is within 70 miles. These two centers of population are sufficiently close to serve as an adequate market for over half of the Study Area.

One unfavorable factor is lack of a broad manufacturing base. New industries would require a reservoir of labor with skills different than those upon which the Area primarily depends now. This would mean that new industries would require other favorable factors sufficient to offset the expense of training the indigenous labor for the required skills. This is not to say that these skills are not now present in the Area, but, as Table VI-1 shows, there are no large reservoirs of skills other than in textiles, apparel, food processing, and furniture and lumber. This lack of sufficiency and range of skills will tend to retard manufacturing.

With these favorable and unfavorable factors in mind, then, manufacturing employment is projected, as shown in Table VI-1, to the year 1985. As a percent of total employment, apparel and food processing are projected to realize the largest gains. Apparel is projected to increase from 1.0 percent (1,398) of total employment in 1960 to 3.5 percent (6,000) in 1985. Food processing is projected

to increase from 1.6 percent (2,310) of total employment in 1960 to 3.4 percent (5,900) in 1985. Textiles will still be the largest employment category by 1985 but will have declined as a share of total employment.

Labor, historically, has been a significant factor in textile mill production, and the relatively cheap labor supply was the initial reason textiles moved to the Study Area. However, advancement in technology has made it possible to reduce the labor component of production. Projections of the textile industry are for rapid modernization of old and new plants and for a greatly increased dependence upon higher skills with an over-all reduction of total employment.1/ These trends will tend to reduce the Area's advantage based upon cheap, unskilled labor and tend to hold textile employment to the 1960 level of about 10,000 employees.

The table below presents projected output indices. All the indices are based upon national trends in Gross Output Originating per employee as presented by the National Planning Association.2/

Industry	Index of Output		
	1960	1975	1985
Food	100	273	481
Textiles	100	142	175
Apparel	100	494	730

Of these three major industries, apparel output is projected to realize the greatest gain in output. According to Technological Trends, apparel manufacturing, especially of outerwear, will continue to rely heavily upon semi-skilled labor, primarily women. A surplus of female labor will tend to induce expansion of apparel plants.

Food processing will depend more upon the production of agricultural products leading to canning and preserving. As mentioned in the agricultural discussion above, these type products are expected to expand.

1/ Technological Trends in Major American Industries. Bulletin No. 1474, U.S. Department of Labor, February 1966.

2/ American Industry in 1976 and 1985: Projections of Output, Employment, and Productivity. National Economic Series, Report No. 64-1, February 1964.

The next most important industries other than those mentioned above are machinery and electrical machinery, machinery employment increasing from 676 employees in 1960 to 2,600 by 1985 and electrical machinery employment increasing from 464 in 1960 to 3,300 by 1985. Furniture, lumber, and wood products employment is expected to maintain its 1960 employment of approximately 4,000.

4. Population

Population projections were derived from the employment projections shown in Table VI-1. As the figures indicate, population is expected to increase moderately, averaging approximately 1.0 percent per annum.

Urban population is expected to increase from 30.6 percent (122,314) of total population in 1960 to 55.0 percent (264,000) in 2025. The water service area in Table VI-1 is a larger area than the urban area, but an urban area always serves as the center. Generally, a water service area includes the minor civil divisions the urban center is in. Water service area population in the Study Area is expected to increase from 167,829 in 1960 to 337,600 in 2025.

Table VI-1
Tar River Study Area 1/
Employment and Population
Historical and Projected
1950-2025

Industry	1950			1960			1975		1985	
	Number	Pct.	L.Q. 2/	Number	Pct.	L.Q.	Number	Pct.	Number	Pct.
Agr., For., & Fish.	73,278	50.9	1.71	60,755	41.8	2.04	42,200	26.5	36,500	21.1
Mining	351	0.2	1.14	270	0.2	1.12	220	0.1	220	0.1
Construction	4,721	3.3	0.78	5,835	4.0	0.79	8,300	5.2	10,000	5.8
Manufacturing	19,993	13.9	0.49	22,781	15.7	0.51	30,510	19.2	36,630	21.2
Furn., Lum., & Wd. Prod.	5,083	3.5	0.69	3,979	2.7	0.62	4,000	2.5	4,000	2.3
Primary Metals	10	---	0.06	38	---	0.21	70	---	100	0.1
Fabricated Metals	99	0.1	0.37	208	0.1	0.29	300	0.2	200	0.1
Machinery, exc. Elec.	138	0.1	0.25	676	0.5	0.66	1,500	0.9	2,600	1.5
Electrical Machinery	56	---	0.11	462	0.3	0.22	1,500	0.9	3,300	1.9
Transportation Equip.	85	0.1	0.67	163	0.1	0.50	200	0.1	230	0.1
Other Durables	330	0.2	0.42	403	0.3	0.37	550	0.4	700	0.4
Food & Kindred Prod.	1,594	1.1	0.74	2,310	1.6	0.89	4,000	2.5	5,900	3.4
Textile Mill Prod.	9,938	6.9	0.44	10,171	7.0	0.49	10,000	6.3	10,000	5.8
Apparel & Related Prod.	81	0.1	0.07	1,398	1.0	0.43	4,850	3.1	6,000	3.5
Print., Pub., & Allied Prod.	334	0.2	0.53	459	0.3	0.53	600	0.4	700	0.4
Chemicals & Allied Prod.	569	0.4	0.70	795	0.6	0.63	940	0.6	900	0.5
Tobacco	1,676	1.2	0.45	900	0.6	0.30	800	0.5	500	0.3
Other Nondurables				819	0.6	0.51	1,200	0.8	1,500	0.9
Trans., Comm., & Util.	4,807	3.3	0.86	4,834	3.3	0.80	4,880	3.1	4,950	2.9
Wholesale & Retail Trade	17,790	12.3	0.86	21,146	14.6	0.94	28,700	18.0	34,030	19.7
Finance, Ins., & Real Est.	1,554	1.1	0.65	2,846	2.0	0.71	5,210	3.3	6,200	3.6
Services	13,136	9.1	0.88	14,690	10.1	0.87	18,150	11.4	20,770	12.0
Government	8,425	5.8	0.83	12,071	8.3	0.91	20,940	13.2	23,700	13.7
Total Employment	144,055			145,228			159,110		173,000	

(Continued)

Table VI-1

	1950	1960	1975	1985	2000	2025
Population	396,106	399,424	420,500	440,000	460,000	480,000
Urban Area	101,994	122,314	147,200	169,000	207,000	264,000
Water Service Area	150,456	167,829	209,950	231,320	270,900	337,600

1/ The population of the Study Area consists of the following counties: Beaufort, Edgecombe, Franklin, Granville, Halifax, Hyde, Nash, Pitt, Vance, and Warren.

2/ The portion of total employment in the Study Area that is employed in an industry relative to the same industry's total employment in North Carolina as a portion of North Carolina's total employment.

VII. WATER SUPPLY

PRESENT WATER USE

Present water use and sources for the six major municipalities in the basin are indicated in the following table:

Municipality	Approximate Water Use (mgd)	Source
Oxford	1.5	Tar River & Tributaries
Rocky Mount	8.5	Tar River
Henderson	2.0	Sandy Creek
Tarboro	1.0	Tar River
Greenville	3.0	Tar River
Washington	1.0	Tranters Creek

All major industries in the basin obtain their water from municipal systems with the exception of the Rocky Mount and Greenville steam power plants. The two plants use approximately 38 mgd of water from the Tar River for cooling purposes.

There are a number of irrigation intakes on the major tributaries and main stem of the Tar River. Water is primarily used for tobacco and it is anticipated that the use will increase in the future. However, because of the restrictions on tobacco production and the small number of acres under cultivation, the effect of irrigation on the water resources of the basin will be small.

The present water use in gallons per capita day (gpcd) varies from 100 to 165 depending upon the industrial demand. Trends in water use indicate a substantial increase in industrial growths at Rocky Mount, Greenville and Oxford.

FUTURE WATER SUPPLY NEEDS

Based on the projected economic and demographic data, the following municipal and industrial water supply needs are projected for the major municipalities in the basin.

Municipalities	1980 (mgd)	2000 (mgd)	2025 (mgd)
Oxford	2.0	3.0	3.5
Rocky Mount	10.0	14.5	22.5
Henderson	2.5	3.2	4.0
Tarboro	1.3	2.0	2.7
Greenville	4.0	6.5	10.5
Washington	1.3	1.5	2.0

The municipalities of Oxford, Rocky Mount and Henderson require additional water supply if they are to meet future demands. Each of these communities has proceeded to develop preliminary engineering plans for expansion of existing facilities.

The City of Rocky Mount is planning to construct a reservoir on the Tar River below the proposed Corps of Engineers' Spring Hope site. The reservoir will yield between 70 and 100 mgd, which will supply the City much beyond 2025.

The City of Henderson is currently expanding its present system and will take water from the John H. Kerr Reservoir. This supply will meet all future needs of the City.

The City of Oxford's main source of water is obtained from the headwaters of the Tar River. The hydrology of the area is such that during dry periods the Tar River flow diminishes considerably and inflow to Lake Devin, a small storage reservoir, is negligible. The City has had water shortages in the past and is currently considering the construction of a small impoundment on the Tar River, which will yield approximately 10 mgd. This proposal is currently in the planning stages. The proposed Corps of Engineers' Grey Rock Reservoir, if constructed in the near future, could meet the need for the City of Oxford.

The municipalities of Tarboro and Greenville presently obtain their water from the Tar River. Low flows of the river at the water supply intakes for these municipalities are sufficient to meet their needs through 2025.

The City of Washington presently obtains its water supply from Tranters Creek, a tributary to the Tar River. Additional water, when needed, could be obtained from the Tar River at a point above Greenville.

VIII. WATER QUALITY CONTROL

GENERAL

The waters of the Tar River Basin are natural resources upon which economic growth, health and welfare, recreation, fish and wildlife, and the general aesthetics of the basin are dependent. If the quality of the water resources of the basin is reduced to a a level which would not meet the requirements of the beneficial users tangible economic losses in terms of limited economic growth, reduction of fishing potential, and lower recreation values, will result.

The water quality may be adversely affected by domestic waste, industrial waste, irrigation return flows and natural sources of pollution. In the Tar River Basin there are no significant natural sources of pollution and irrigation return flows are small, having little influence on the receiving streams. Domestic and industrial wastes are the primary sources of pollution in the basin.

Water quality may be partly maintained by providing waste treatment facilities which will reduce the concentrations of waste discharged to the receiving stream. In accordance with the requirements of the North Carolina Board of Water and Air Resources secondary treatment will be provided for all waste sources in the basin before 1975. For the purpose of this study secondary treatment providing a minimum of 85 percent removal of organic wastes as measured by BOD was considered to provide adequate treatment; however, residual waste loads remaining after treatment based on future estimates will exceed the assimilative capacity of the receiving streams during periods of low flow.

The assimilative capacity of a stream may be considered as the capacity or ability to partially satisfy the BOD exerted by a degradable waste discharge to a stream. The assimilative capacity is dependent upon the rate at which a waste breaks down, the initial dissolved oxygen in the stream, the ability of the stream to reaerate or replenish depleted dissolved oxygen, and the concentration of BOD in the stream.

If, after providing secondary treatment, the assimilative capacity of the stream is exceeded other quality control methods such as advanced waste treatment, stream aeration, and flow augmentation need to be evaluated to determine what future steps should be taken to protect the adopted water uses in the basin.

PRESENT WASTE SOURCES

At present there are 27 significant waste sources in the basin of which 19 provide secondary treatment, 6 primary treatment, and 2 provide for treatment of inorganic wastes. The total waste load generated in the basin is approximately 15 mgd with a P.E. of 153,000. The mean efficiency for all treatment plants is about 80 percent in terms of BOD removal, leaving a P.E. of 31,000 being discharged to the receiving stream. Secondary treatment will be provided at all sources of organic waste now providing only primary treatment. These facilities are either under construction or in the planning stage.

There are four major municipalities in the basin of which three contribute all their wastes to the Tar River and the fourth city, Henderson, contributes approximately 15 percent to the Tar Basin with the remaining discharged to the Roanoke River Basin. The municipalities of Rocky Mount, Tarboro, and Greenville currently discharge approximately 12,500, 1,650 and 5,300 P.E.'s respectively, to the Tar River which represents 55 percent of the basin's waste load. A summary of all waste sources is presented in Table D of the Appendix.

The majority of industrial wastes in the basin are treated by the municipalities. The only significant untreated industrial discharges are those of the Rocky Mount and Greenville power plants, which discharge about 38 mgd of cooling water. At present no adverse thermal effects have been found in the Tar River.

There are two major sources of inorganic waste in the basin which are not connected to municipal systems, an electronic plant in Oxford, and a rock quarry near Rocky Mount. Plating wastes from the electronic plant are presently receiving inadequate treatment; however, plans are in process for modification and enlargement of the existing treatment facilities. The wastes from the rock quarry are presently receiving adequate treatment in settling ponds.

Minor sources of organic pollution which contribute to the total waste load entering the receiving streams are storm runoff from urban areas, individual waste discharges and natural land drainage. It has been estimated that organic waste from urban areas can contribute to the receiving stream from five to nine percent of the total waste treated and that the natural pollution in the basin is approximately 1 mg/l of BOD.

FUTURE WASTE ESTIMATES

Municipal and industrial waste projections for the study area were made utilizing data for estimated population and industrial growth presented in Chapter VI The Economy. Major waste producing industries are in the field of food, textiles, and apparel. Industrial waste projections were based on the trends for industrial expansion and gross output.

Sanitary waste projections were based on estimated population growth for water and sewer service areas. The projected future waste loads and discharges to receiving streams for most significant areas for the years 1980, 2000, 2025, are presented in Table VIII-1.

TABLE VIII-1
MUNICIPAL AND INDUSTRIAL WASTE ESTIMATES

Municipalities	Population Equivalents 1980	2000	2025
Rocky Mount Municipal and industrial waste loadings after treatment	15,500	21,000	33,000
Tarboro Municipal and industrial waste loadings after treatment	2,000	2,800	3,900
Greenville Municipal and industrial waste loadings after treatment	6,000	10,000	15,000
Washington Municipal and industrial waste loadings after treatment	1,800	2,200	2,500
Oxford Municipal and industrial waste loadings after treatment	1,400	1,800	2,400

WATER QUALITY STANDARDS

Present water quality and stream uses were evaluated and it was determined that coliform bacteria and dissolved oxygen were the most significant quality standards that must be maintained to protect the present and future uses of the basins streams.

The North Carolina Department of Water and Air Resources has established Water Quality Standards and stream uses for all waters in the Tar River Basin. The following Table indicates the water uses to be protected on the main stem of the Tar River.

STREAM USES

Reach	Classification	Best Usage
Source to Rocky Mount Water Supply Intake	A-II	Water Supply
Rocky Mount Intake to Beech Branch	C	Fishing
Beech Branch to Tarboro Water Supply Intake	A-II	Water Supply
Tarboro Intake to Suggs Creek	C	Fishing
Suggs Creek to Greenville Water Supply Intake	A-II	Water Supply
Greenville Intake to Washington	C	Fishing

A minimum dissolved oxygen level of 4.0 mg/l has been adopted for the above classification and the coliform concentration for reaches designated as water supply must meet the recommendations contained in the Public Health Bulletin No.296, Manual of Recommended Water Sanitation Practice, recommended by the U. S. Public Health Service, 1946; and for recreational waters an objective of 200 fecal coliform per 100 ml has been proposed, and in addition emphasis is placed upon a sanitary survey of the waters proposed for water contact sports.

Water supply and recreational uses in the basin will be protected through disinfection of the wastes at the source. Fishing usages can be maintained in the basin at the present through the provision of secondary treatment for all waste sources in the basin. To maintain this usage in the future, advanced waste treatment and/or flow regulation will be necessary.

The most feasible basin plan for maintaining beneficial water uses are discussed in the next section.

WATER QUALITY CONTROL PLAN

Various waste loadings based on economic projections, basin hydrology, and assimilative stream capacities were evaluated using a mathematical model to determine the effects of various water quality control measures on water quality for maintenance of fish propagation. It was found that secondary waste treatment facilities with a minimum efficiency of 85 percent as measured by total BOD removal would protect the receiving stream until 1980. After 1980 higher efficiencies of waste treatment or flow regulation would be required.

Utilizing a mathematical model and digital computer the flow regulation necessary for assimilating future waste loads and maintaining a minimum of 4.0 mg/l dissolved oxygen during low streamflow conditions are presented in the following table.

TABLE VIII-2
Required Streamflow for Water Quality Control Tar River at Rocky Mount - (cfs)

Month	1980	2000	2020
January	8	9	10
February	8	9	10
March	17	20	22
April	25	30	35
May	31	35	49
June	40	46	70
July	48	55	82
August	44	50	76
September	38	43	64
October	25	30	35
November	17	20	22
December	8	9	10

The above streamflows are not release schedules but are the estimated streamflows required in the critical reach and are based on economic projections and associated waste loads. These flows were used for determining reservoir storage requirements. Water quality releases should be made on the basis of stream needs as determined by the responsible water pollution control agency from data obtained through water quality monitors.

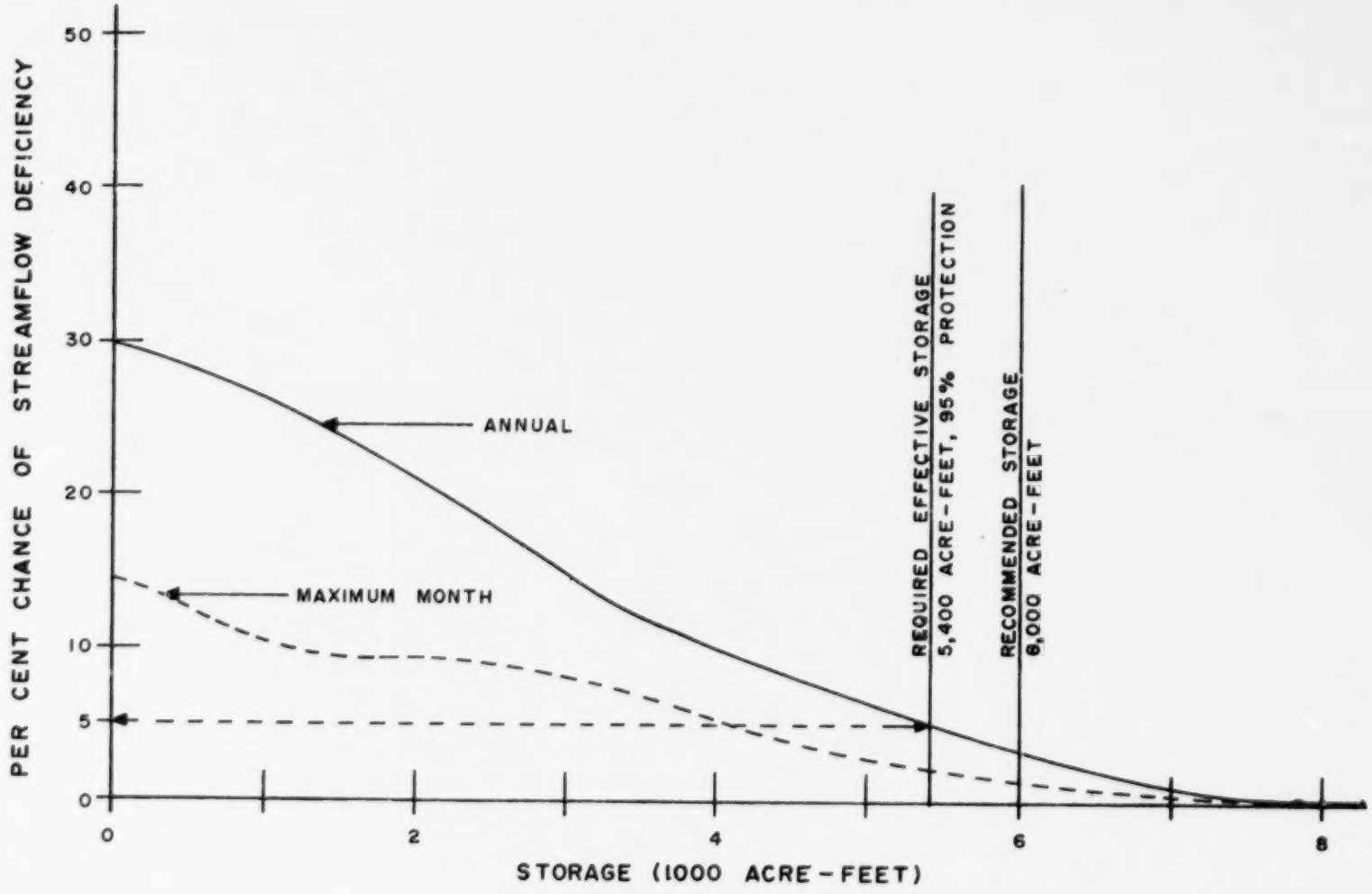
Hydrological data were analyzed to evaluate the adequacy of various reservoir storages at the proposed Spring Hope site to meet the flow requirements. Streamflow sequences (representing a 500 year period) that preserved the statistical characteristics of the available data were generated by operational hydrology and utilized in the analysis. These flows were routed through reservoirs of various sizes to define how well the flow requirements presented in Table VIII-2 were met.

Based on this analysis it was determined that 5,400 acre-feet of storage would provide sufficient water for flow regulation such that there would be no more than a 5 percent chance in any given year that there would be a deficiency in the required streamflow for periods exceeding one month. Because of the many variables involved in the analysis and the small storage requirements an effective storage of 6,000 acre-feet is recommended. The percent chance of annual and maximum monthly streamflow deficiencies are plotted against storage in Figure 2 for the Spring Hope site.

With the provision of 6,000 acre-feet of effective storage there will be no more than a 3 percent chance in any given year that the dissolved oxygen will drop below 4.0 mg/l for a period exceeding one month. There will be less than a one percent chance that the dissolved oxygen will drop below 3.0 mg/l for a period exceeding one month. This will usually occur during the summer months and would not result in a total contravention of beneficial uses, as it is recognized that warm water fish will survive for extended periods at dissolved oxygen levels in the range of 3.0 mg/l.

A reservoir located at the Spring Hope site would contain 6,000 acre-feet of flow regulation storage and 5,000 acre-feet of evaporation and sedimentation storage for a total of 11,000 acre-feet.

Average annual costs including maintenance and capital amortization at 3 1/8 percent for 50 years are estimated at $74,700. This proposal will protect the water usage for fish propagation and in addition intangible benefits such as improvement of overall water quality, stabilization of water levels and aesthetics, will be realized.



PER CENT CHANCE OF ANNUAL & MAXIMUM MONTHLY STREAMFLOW DEFICIENCIES
VS
STORAGE REQUIREMENTS - SPRING HOPE SITE FOR YEAR 2025

Figure 2

VIII-6.A

The water use for fishing and fish propagation can be protected beyond 1980, by providing advanced waste treatment and reducing the BOD load entering the receiving stream. In order to protect the main stem of the Tar River, advanced waste treatment plants will need to be constructed at Rocky Mount and Greenville. The plants would be stage constructed with the initial phase constructed in 1980, and second stage in 2000. The estimated average annual cost for both plants including maintenance and capital amortization at 3 1/8 percent is estimated at $173,100.

Although advanced waste treatment would achieve the established quality objectives, the intangible benefits would be somewhat less than those gained by flow regulation.

A comparison of average annual cost indicated the best plan for maintaining the water quality objective in the Tar River Basin would be to provide a single purpose reservoir at the Spring Hope site. In addition, the municipalities in the basin would have to provide secondary treatment with a minimum efficiency of 85 percent as measured total BOD removal and disinfection of the plant effluents.

Because of poor water quality associated with thermal stratification, a multi-level outlet structure should be incorporated in the design to permit the release of water high in dissolved oxygen. The multi-level outlet will also provide for the passage of fish from the reservoir to the tailwaters. Stream monitoring equipment should be installed downstream to provide information to be used for determining reservoir releases and developing a water quality management program for the basin.

IX. BENEFITS

WATER SUPPLY

The City of Oxford is the only municipality in the Tar River Basin for which water supply benefits need to be considered, since the remaining communities have either adequate sources or are nearing construction of adequate water supplies. The water supply benefits for the City of Oxford would be equal to the cost of a single purpose reservoir located on the Tar River with a storage capacity of approximately 5,900 acre-feet. The City's consulting engineer has estimated the initial cost to be $420,000. The average annual benefit based on a 50-year amortization at 3 1/8 percent interest plus operation and maintenance cost is estimated to be $16,700.

WATER QUALITY CONTROL

Benefits attributable to water quality control may be defined as the increase in the value of goods or services which results from water quality control measures as compared with the conditions that would result without quality control. The benefits include tangibles and intangibles which may be differentiated as those benefits that can be expressed in monetary terms, and those that are recognized as having real value in satisfying human needs but not fully measurable in monetary terms.

The value of the benefits may be determined by assessing the damages in the absence of water quality control such as preclusion of economic activity, loss of recreational opportunities, increased municipal and industrial water treatment cost, loss of industrial production, impairment of health and welfare, damage to fish and wildlife, and degradation of aesthetics.

Significant damages that would result in the Tar River in the absence of water quality control measures are degradation of aesthetics, loss of recreational opportunity, reduction of fish population, and increased water treatment costs. The damages to the beneficial water uses are related to the basin's hydrology, population increase and industrial growth. By 1980 it is expected that water quality will begin to drop below recommended quality standards during low flow periods and the degradation of water quality will increase each year thereafter. The greatest losses will be those associated with the basin's fishery and aesthetics.

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If water quality control measures are not provided, the beneficial stream uses could be protected through restriction of industrial growth which would reduce the total waste load discharged to the basin's streams. However, the economic loss to the basin would be large and over a period of years would probably exceed the cost of adequate water quality control measures such as advanced waste treatment or flow regulation. In Section VIII of the report, a preliminary evaluation indicated that a flow regulation plan is the most economical approach; and it would provide for maintenance of beneficial water uses, compliance with established water quality standards and normal economic growth within the basin.

The value of benefits derived from such a river basin plan is equal to the sum of the values for each individual use. At present a suitable rational is not available for determining these values and the tangible benefits which can be estimated only reflect a portion of the total benefits to be derived from the river basin plan. A qualitative evaluation of the value of benefits are presented below for the most significant stream uses.

The additional cost for municipal water treatment was investigated, and the cost was found to be negligible. The City of Greenville reported an increase in the use of activated carbon during low flow periods, but indicated the increased cost was quite small. The City is in favor of flow regulation for improved water quality, but indicates the benefits to water supply would be intangible.

The value of recreational benefits which are attributed to the main stem of the Tar River was not determined. At present the river is not classified for water contact sports; and the use of the stream for these purposes will depend upon access, land use and other factors. Benefits from water associated recreation and aesthetics would be realized, but the value is intangible. The potential for water associated recreation can be related to the population of the basin which is expected to reach 420,500 in 1975, and increase to 480,000 in 2025. The importance of water oriented recreation in the basin is indicated by the expected annual attendance of 2,156,000 persons in 1995 for the four proposed reservoirs.

The value of fishing benefits for the Tar River from Rocky Mount to a point below Greenville, approximately 90 miles, was evaluated by the U. S. Bureau of Sport Fisheries and Wildlife. The benefits were based on percent of standing crop reduction for various dissolved oxygen levels during low flow periods. The percent reduction for resident fish species was zero at a dissolved

oxygen level of 4.0 mg/l and increased to 100 at 2.0 mg/l. The reduction in the shad fishery reached 100 percent at 2.5 mg/l. Using this rational the average annual value for sport fishing was determined to be $5,100 and represents 4,100 fisherman mar days. The annual value of the fishery which is being protected is estimated to be $64,800.

APPENDICES

APPENDIX A

Analytical Results of Selected Stations
North Carolina State Dept. Water Resources
Stations Sampled 1958

Station	Discharge cfs	Temp °C	Turbidity Units	pH Range	Hardness $CoCo_3$ mg/l	Chloride mg/l	D.O. mg/l	5-Day BOD mg/l @ 20°C	Coliform MPN per 100 ml	Location
3	33	29	95	6.8-7.3	27	3	7.1	1.3	410	Tar River near Tar River above Pollution from Fishing Creek
6	1.6	22	60	6.9-7.8	76	32	2.2	9.7	17×10^6	Fishing Cr. near Oxford
14	70	23	85	6.8-7.4	31	5	8.3	1.5	1400	Tar River below Pollution of Fishing Creek
20	117	22	40	6.7-7.3	26	4	7.6	1.5	1.1×10^5	Tar River below Louisburg
26	28	22	29	7.1-7.4	22	3	7.9	1.0	2800	Cedar Creek
27	228	23	60	7.0-7.3	25	3	7.3	1.6	14000	Tar River below Pollution from Louisburg & Franklinton
37	12	23	20	6.7-7.2	28	4	5.9	1.9	1600	Sapony Creek
38	328	23	50	7.0-7.4	26	3	7.9	1.0	620	Tar River below Sapony Creek
53	270	24	80	6.9-7.4	29	13	6.5	2.5	8.5×10^5	Tar River below Rocky Mount
66	120	25	30	6.7-7.4	24	3	6.8	2.1	940	Swift Creek
67	582	25	70	6.8-7.4	23	7	6.9	2.1	11000	Tar River below Swift Creek
94	950	24	65	6.8-7.2	30	6	6.8	1.3	1.9×10^5	Tar River below Tarboro
105	25	22	25	6.6-6.9	31	6	6.7	1.6	650	Town Creek
106	960	25	60	6.9-7.3	30	5	6.8	1.5	1.8×10^5	Tar River below Town Creek

Appendix A (Cont'd)

Station	Discharge cfs	Temp oC	Turbidity Units	pH Range	Hardness CoCo3 mg/l	Chloride mg/l	D.O. mg/l	5-Day BOD mg/l @ 20°C	Coliform MPN per 100 ml	Location
118	1580	25	45	6.4-7.0	25	5	5.7	1.9	1.0×10^5	Tar River below Greenville
125	1820	27	60	6.7-7.0	27	6	6.0	1.8	1.0×10^5	Tar River above Washington
152	1560	29	25	6.8-8.9	91	190	7.6	3.5	140	Pamlico River below Washington
155	1790	28	10	6.8-7.8	557	1400	6.6	1.9	50	Pamlico River below Washington

APPENDIX B

Chemical Analysis of Surface Water (Raw)
Tar River

(Milligrams per Liter)

Location	Iron	Sulphate	Chloride	Fluoride	Dissolved Solids	Total Hardness
Franklinton	0.35	6.7	3.8	0.1	48	13
Greenville	0.49	5.8	10	0.2	75	26
Henderson	0.2	1.3	6.8	0.1	42	11
Louisburg	0.02	4.1	4.5	0.1	56	19
Oxford	0.1	8.2	3.2	0.1	48	11
Rocky Mount	0.06	3.6	6.0	0.1	61	17
Tarboro	0.57	4.4	6.5	0.1	68	25
Warrenton	0.40	0.5	4.0	0.4	59	24
Washington	0.53	6.0	6.5	0.0	70	13

APPENDIX C

Chemical Analysis of Groundwater
Tar River Basin
(Milligrams per Liter)

Location	Iron	Sulphate	Chloride	Fluoride	Dissolved Solids	Total Hardness
Battleboro	0.23	6.4	5.0	0.2	250	162
Bethel	-	110	190	1.0	-	24
Elm City	0.0	20	10	0.1	220	124
Littleton	0.03	14	6	1.7	143	84
Nashville	0.16	3.3	4	0.2	102	50
Pinetops	0.0	7.8	4	0.4	139	79
Robersonville	0.43	8.4	16	0.9	420	10
Scotland Neck	0.04	4.1	14	0.3	78	20
Spring Hope	0.02	6.1	3	0.2	124	80
Washington	0	16	104	0.7	-	168
Whitaker	1.8	12	9	0.0	73	25

APPENDIX D

TAR RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE DISCHARGES

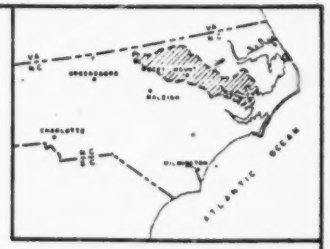
Source of Waste	Est. Pop. Served	Average Daily Flow mgd	P.E. Before Treatment	P.E. After Treatment	Degree of Treatment	Receiving Stream
Battleboro	450	0.025	450	225	Primary	Beech Br. to Fishing Cr. to Tar R.
Bethel	1,500	0.115	1,500	1,275	Primary	Grindle Cr. to Tar River
Elm City	919	0.046	919	92	Stabilization lagoon	Town Cr. to Tar R.
Enfield	2,544	0.305	2,544	381	Secondary	Jacket Swp. tributary to Jacket Swp. to Beech Swp. to Fishing Cr. to Tar River
Franklinton	1,300	0.128	1,000	150	Secondary, Cl_2	Franklinton Br. to Cedar Cr. to Tar R.
Burlington Ind., Franklinton Fabrics Plant	-	350	-	-	-	-
Greenville						
Northside Plant	300	0.0075	300	45	Rated aeration	Unnamed tributary to Parkers Cr. to Tar River
Water Pollution Control Plant	28,000	3.50	35,730	5,256	Secondary Cl_2	Tar River
Henderson						
Red Bud Cr. Plant	-	0.132	10,920	393	Secondary Cl_2	Red Bud Cr. to Ruin Cr. to Tabbs Cr.

APPENDIX D (Cont'd)

Source of Waste	Est. Pop. Served	Average Daily Flow mgd	P.E. Before Treatment	P.E. After Treatment	Degree of Treatment	Receiving Stream
Littleton	1,200	0.150	1,782	267	Secondary	Butterwood Br. to Bear Swp. to Little Fishing Cr. to Fishing Cr.
Louisburg	2,435	0.260	2,435	275	Secondary	Tar River
Macclesfield	370	0.037	370	277	Primary	Briery Br. to Bynum Mill Run to Bynum Mill Cr. to Town Cr. to Tar River
Nashville	1,700	0.140	1,700	1,530	Primary	Stony Cr. to Tar River
Oxford						
Northside Plant	5,300	0.201	6,462	306	Secondary	Jordan Cr. to Coon Cr. to Fishing Cr. to Tar River
Southside Plant	3,500	0.261	8,448	210	Secondary	Unnamed tributary to Fishing Cr. to Fishing Cr. to Tar River
J.F.D. Electronics	-	0.0041	-	-	Plating waste treatment by Batch method for reduction of chromium, nickel, cyanide	Unnamed tributary to Hatchers Run to Fishing Cr. to Tar River
Pinetops	2,200	0.200	2,202	50	Secondary	Town Cr. to Tar River
Rocky Mount	33,000	7.00	51,924	12,528	Secondary	Tar River
Robersonville	1,850	0.150	4,659	700	Secondary, Cl_2	Flat Swp. Canal to Flat Swp. to Tranters Cr.
Scotland Neck	2,800	0.330	3,300	2,450	Primary	Canal Cr. to Deep Cr. to Fishing Cr. to Tar River.

APPENDIX D (Cont'd)

Source of Waste	Est. Pop. Served	Average Daily Flow mgd	P.E. Before Treatment	P.E. After Treatment	Degree of Treatment	Receiving Stream
Scruggs Poultry Rocky Mount	-	0.003	94	14	Lagoon, 2.0 acres	Unnamed tributary to Stony Cr. to Stony Cr. to Tar R.
Spring Hope	1,350	0.135	960	294	Secondary	Hendricks Cr. to Sapony Cr. to Tar River
Tarboro	9,000	0.597	7,350	1,638	Secondary	Tar River
Riverside Apts. (Long Mfg. Co.)	135	0.0014	135	34	Secondary	Tar River
Warrenton	1,300	0.130	1,300	195	Secondary	Fishing Cr. to Tar R.
Washington	10,000	1.260	5,736	1,200	Secondary, Cl_2	Kennedy Cr. to Tar R.
Whitakers	800	0.050	800	720	Primary	White Oak Swp. to Tar R.
Waste from Mining Operations						
Rocky Mount Quarry-Nello L. Teer Co.	30	0.400	Inorganic		D.S.-Pit Privies I.W.-Settling Ponds	Maple Cr. to Tar River



LOCATION MAP

SCALE IN MILES

WATER SUPPLY & WATER QUALITY CONTROL STUDY
MIDDLE ATLANTIC DRAINAGE AREA

TAR RIVER BASIN

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

D-4

FIGURE 1

GRANVILLE
VANCE
WARREN
WARRENTON
OXFORD
HENDERSON
HALIFAX
ENFIELD
SCOTLAND NECK
GREY ROCK DAMSITE
TAR RIVER
LOUISBURG
WHITE OAK DAMSITE
FRANKLIN
NASH
RED OAK DAMSITE
NASHVILLE
ROCKY MOUNT
TARBORO
SPRING HOPE DAMSITE
EDGECOMBE
MARTIN
WILSON
GREENVILLE
WASHINGTON
PITT
BEAUFORT
PAMLICO
AURORA

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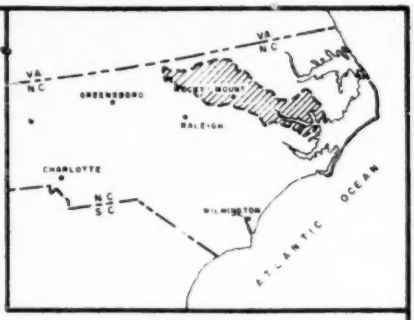

LOCATION MAP

SCALE IN MILES

10 0 10 20 30 40

WATER SUPPLY & WATER QUALITY CONTROL STUDY
MIDDLE ATLANTIC DRAINAGE AREA

TAR RIVER BASIN

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

D.4

FIGURE 1

B

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